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PECULIAR EFFECTS OF BARIUM, STRONTIUM, AND CERIUM ON SPIROGYRA

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(WITH TWO FIGURES)

It has been pointed out by OSTERHOUT[1] that dilute solutions of $BaCl_2$ (0.001–0.0001 M) have a specific effect on certain species of *Spirogyra*. They produce a peculiar contraction of the chloroplasts in the middle of the cell which is very characteristic. This effect was not produced at this dilution by any of the other salts examined. As specific effects of this kind are uncommon, it seemed desirable to investigate the matter further.

Two species of *Spirogyra* were investigated, a large form of the *S. crassa* type, which was used by OSTERHOUT, and a smaller species. The method of contraction differs somewhat in the two species. In both kinds contraction usually begins in the region near the ends of the cell, but in the larger kind the chloroplasts sometimes begin to contract in the central region. In a large percentage of the cells of the larger kind the central region shows the greatest contraction. The chloroplasts in this region may either shrink away from one side of the cell wall more than from the other, or equally from all sides. In the latter case the final shape (fig. 1, *B*) assumed by these bodies is quite typical for this kind of *Spirogyra*. In the smaller kind the greatest shrinking occurs in regions between the center and the ends of the cell (fig. 2, *B*). These are cells of the larger kind, however, whose chloroplasts contract like those of the smaller kind, and vice versa. In general the longer cells of each species are apt to contract most toward the ends, while the shorter cells are apt to have the greatest contraction in the middle. In either case the contractions of the chloroplasts are very characteristic.

Contraction usually takes place a few minutes after the application of the solutions. Table I shows the time necessary for producing the effect at different solutions.

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[1] OSTERHOUT, W. J. V., Specific action of barium. Amer. Jour. Botany 3:481–482. 1916.

The last named dilution of each salt is the lowest dilution at which contraction appears. $CeCl_3$ produces contraction of the larger kind only. It is also seen from the table that the lower limit of $CeCl_3$ solution which produces the effect is less than that of the $BaCl_2$ solution, but the table shows that the effect is produced more rapidly in $BaCl_2$ and in $SrCl_2$ than in $CeCl_3$. These

TABLE I

For the larger kind of *Spirogyra*		For the smaller kind of *Spirogyra*	
Solution	Time in minutes	Solution	Time in minutes
$CeCl_3$ 0.005 M	8	$BaCl_2$ 0.05 M	1–2
0.001 M	9	0.01 M	2–5
0.0005 M	9	0.001 M	15
0.0001 M	9		
0.00005 M	10	$SrCl_2$ 0.05 M	2–3
		0.01 M	3–4
$BaCl_2$ 0.005 M	4		
0.001 M	5		
0.0005 M	7		
$SrCl_2$ 0.01 M	2.5		
0.005 M	12		

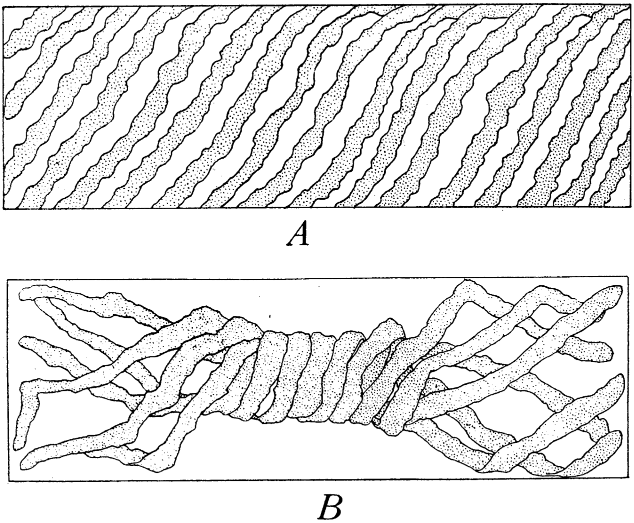

FIG. 1.—*Spirogyra: A*, normal condition; *B*, after treatment with $BaCl_2$

two kinds of *Spirogyra* are different also in respect to the phenomena of antagonism, which will be discussed later.

If a contraction appears only after some hours or days, it is disregarded, as in such long experiments complicating factors are present. Solutions of barium and strontium salts in lower concentrations than those indicated will not produce the effect in 24 hours. With other salts which usually do not produce the effect contractions sometimes appear after 3 or 4 hours (or after several days), but this may be due to other agencies than the salts, because in material dying from natural causes cells with contracted chromatophores are sometimes found.

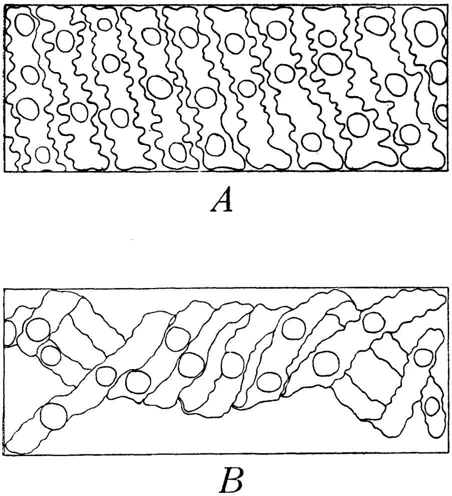

FIG. 2.—*Spirogyra:* large form, *crassa* type, pyrenoids omitted; *A*, normal condition; *B*, after treatment with $BaCl_2$.

The material used for this purpose must be fresh and in good condition, or it will lose its sensitiveness and fail to contract when the salts are applied. For example, material was taken at first from a glass jar kept in the greenhouse and was found to be sensitive to both barium and strontium. Later this material deteriorated because of the increased sunlight and heat of the greenhouse, and did not respond to $SrCl_2$, although still responding to $BaCl_2$. Still later it became insensitive to $BaCl_2$ solution, even at the concentration of 0.1 M. The same thing occurred with the small form which grew in a pond. This decrease of sensitiveness seems to be due to some chemical or physical change in the cell when its vitality is injured, which prevents the chromatophores from contracting.

As this visible effect of barium, strontium, and cerium is well suited to the study of antagonism, attempts were made to see what salts hinder or prevent these effects.

Some experiments were made with the smaller kind of *Spirogyra* in order to see whether antagonism occurs. $BaCl_2$ and $SrCl_2$ have no antagonistic action on each other. $CaCl_2$ and $CeCl_3$ (neither of which causes contraction of the chromatophores by itself) are able to antagonize $BaCl_2$, and $CeCl_3$ is more effective than $BaCl_2$. The chromatophores do not contract when placed in a mixture made by adding 10 cc. of 0.04 M $CeCl_3$ to 90 cc. of 0.08 M $BaCl_2$ in an hour and a half (after which the experiment was discontinued); while if 10 cc. distilled water is added to 90 cc. of the same $BaCl_2$, contraction begins after 1.5 minutes. Antagonism is obtained also by mixing 60 cc. of 0.1 M $Cacl_2$ with 40 cc. of 0.1 M $BaCl_2$. In this mixture no contraction occurs in 1 hour, while if 60 cc. of distilled water is used in the mixture in place of $CaCl_2$, the contraction occurs in 2 minutes. The proportions here mentioned are approximately the optimum ones for each mixture.

Summary

1. The chloroplasts of certain species of *Spirogyra* contract away from the cell wall in a peculiar and characteristic fashion in solutions $CeCl_3$, $BaCl_2$, and $SrCl_2$ (in the case of the smaller kind in the last 2 only). The effect is observed in dilutions as great as 0.00005 M $CeCl_3$ (in the case of the larger species), and in 0.0001 M $BaCl_2$. $SrCl_2$ also produces this effect, but not at such great dilutions as $CeCl_3$ and $BaCl_2$.

2. In the smaller species of *Spirogyra* the effect of $BaCl_2$ is inhibited when $BaCl_2$ is mixed with $CeCl_3$ or $CeCl_2$ in proper proportions.

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